Design and Commissioning of a Mobile Multiple-Reflection Time-of-Flight Mass Spectrometer for In-situ Analytical Mass Spectrometry*

J. Lang[1], *W.R. Plaß*[1,2], *T. Dickel*[1,2], *J. Ebert*[1], *H. Geissel*[1,2], *E. Haettner*[1], *W. Lippert*[1], *M. Petrick*[1], *A. Pikhtelev*[3], *C. Scheidenberger*[1,2], *and M. Yavor*[4]

[1]Justus-Liebig-Universität, Giessen, Germany; [2]GSI, Darmstadt, Germany; [3]Institute for Energy Problems of Chemical Physics, Chernogolovka, Russia; [4]Institute for Analytical Instrumentation, RAS, St. Petersburg, Russia

The goal of the LOEWE-Schwerpunkt AmbiProbe [1] is the development of new mass spectrometric tools and methods for in-situ analytics applied to the fields of health, security, and environmental and climate research. In-situ analytics require direct and reliable sampling of ions from the environment and mobile mass spectrometers with minimum infrastructural requirements. Developments within AmbiProbe allow for innovative and hitherto inaccessible applications.

One of these developments is a mobile high-resolution multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS). For the first time, this MR-TOF-MS allows for high-resolution ($m/\Delta m > 10^5$) and highly accurate ($\delta m/m < 10^{-6}$) mass analysis in a mobile device. Strong synergy effects exist with the previously developed MR-TOF-MS [2] for applications in nuclear physics in combination with the cyogenic stopping cell (CSC) at the FRS and Super-FRS [3].

The system consists of several components (Fig. 1): An atmospheric pressure interface (API) with an inlet capillary, differential pumping stages and RF ion guide, to introduce ions from different kinds of atmospheric ion sources. An RF mass filter to suppress contaminents, an RF cooler quadrupole and a subsequent RF ion trap for thermalization and bunching of the ions. This beam preparation system allows for a duty cycle close to 100% for the continously produced atmospheric ions and injects the short ion bunch (< 8 ns) into the coaxial multiple-reflection time-of-flight analyzer. This is traversed many times by the ions to increase the total flight path and thus increase the mass resolving power. The flight time is determined by an MCP detector. The system is placed in a differentially pumped recipient and mounted with all components required for its operation, such as vacuum pumps, power supplies, electronics and data acquisition system in a mobile frame with a total volume of only 0.8 m^3 (Fig. 2). Compared to other high resolution mass spectromteres the setup is small and light and therefore ideally suited for in-situ meassurements.

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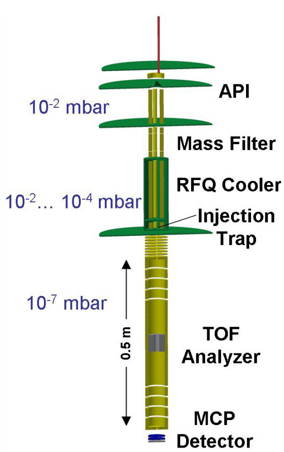

Figure 1: Schematic view of the mobile MR-TOF-MS

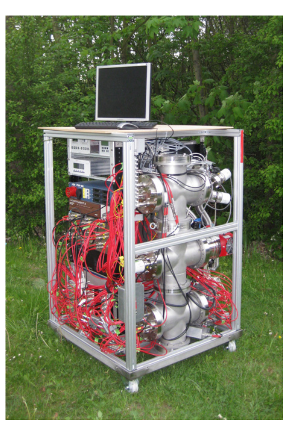

Figure 2: Photograph of the instrument

The MR-TOF-MS has been designed, built and commissioned. A preliminary mass resolving power of $m/\Delta m \approx 100000$ has been achieved and further work is underway to increase the resolving power to several 10^5. Transmission with mass range of a factor 4 (i.e. with a maximum mass that is 4 times larger than the minimum transmitted mass) with constant mass resolving power has been demonstrated. A repetition rate up to 2 kHz features measurements of time-dependent processes such as LC and GC. The mobile MR-TOF-MS offers two different operation modes; a pass-through mode with broad mass range and a multiple-turn mode for high resolution. Further, an ion beam camera has been built for diagnostic purposes and developments of a DAQ, analysis and control software have been done and are ongoing.

The unique combination of high resolution and mobility is of great advantage for various in-situ messurements. Envisaged applications for 2013 are realtime tissue recognition during electro-surgery, in-situ determination of the composition and structure of biomolecules as well as the investigation of soil and water samples. Further developments in automation, ion optics, mass range extension and calibration methods will again provide benificial synergy effects with MR-TOF-MS application in other fields.

References

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